SILICON

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Silicon is a light chemical element with metallic and nonmetallic characteristics. In nature, silicon combines with oxygen and other elements to form silicates. Silicon in the form of silicates constitutes more than 25% of the Earth's crust. Silica is a silicate consisting entirely of silicon and oxygen. Silica (SiO_2) as quartz or quartzite is used to produce silicon ferroalloys for the iron and steel industries and silicon metal for the aluminum and chemical industries. Ferrosilicon and silicon metal are referred to by the approximate percentage of silicon contained in the material and the maximum amount of trace impurities present.

Almost all ferrosilicon products are consumed by the iron and steel industries. In terms of their nominal silicon contents, the two standard grades of ferrosilicon are 50% ferrosilicon and 75% ferrosilicon.

Silicon metal is used by the primary and secondary aluminum industries and the chemical industry, which uses it principally for silicones. Specifications for silicon metal used by the primary aluminum and chemical industries generally are more stringent than those for metal used by the secondary aluminum industry. In addition, the chemical industry requires that the metal be ground into a fine powder rather than the lump form used by the aluminum industry. Silicon metal that is refined into semiconductor-grade metal for use in making computer chips is crucial to modern technology, but the quantity is less than 5% of total silicon metal demand (Roskill's Letter from Japan, 2000). The only information this report contains about this highest purity silicon is as it appears in the foreign trade statistics and from published sources.

For 2003, an overall domestic silicon production of 248,000 metric tons (t) of contained silicon was at its lowest level in 12 years, and represented a decrease of 5% from that of 2002. On a gross-weight basis, production decreased by 11% from that of 2002. Decreases in production were the most notable in the ferrosilicon categories of 25% to 65% silicon content (nominal 50% ferrosilicon) and 56% to 95% silicon content (nominal 75% ferrosilicon), for which the declines were 28% and 27%, respectively, compared with that of 2002. Seventy-five percent (75%) and 50% ferrosilicon shipments decreased by 29% and 27%, respectively. On the basis of contained silicon, U.S. trade volumes of silicon products increased by 11% for imports and by 21% for exports. Imports of 75% ferrosilicon increased 36% compared with those in 2002, and accounted for 57% of silicon imports in 2003. The increase in exports was associated with increases in all silicon metal trade categories. Apparent consumption for ferrosilicon and silicon metal was essentially flat in 2003, with a slight increase in overall silicon apparent consumption to 543,000 t from 541,000 t in 2002. Year-average import prices for the standard grade of 75% ferrosilicon and silicon metal increased 38% and 15%, respectively. The year-average North American transaction price for 50% ferrosilicon rose for the first time in 7 years, increasing by 16% compared with that of 2002 (table 1).

Legislation and Government Programs

On February 11, the U.S. Food and Drug Administration (FDA) issued a revised draft guidance document entitled "Saline, Silicone Gel, and Alternative Breast Implants; Guidance for Industry and FDA" for public comment. The revised draft guidance superseded the guidance dated August 13, 2001 (U.S. Food and Drug Administration, 2003a§[1]). The FDA issued another revised draft document on January 13, 2004, for public review and comment. In the revised draft, FDA clarifies the type and amount of scientific data that should be submitted by industry to allow FDA evaluation of whether the devices are safe and effective. Comments on the latest revised document were due to the FDA by April 12, 2004 (U.S. Food and Drug Administration, 2004).

In October, an advisory panel to the FDA recommended approving a premarket application by Inamed Corporation to bring silicone gel breast implants back on the U.S. market. The General and Plastic Surgery Devices Panel's recommendation for implant sales was contingent upon mandatory health tracking, patient education, and long-term studies on the health effects of silicon in the body (Chemical Week, 2003c; U.S. Food and Drug Administration, 2003b§).

Production

Silicon Ferroalloys and Metal.—In terms of gross weight and in comparison with those of 2002, overall domestic gross production, net shipments, and stocks of silicon products decreased by about 11%, 10%, and 28%, respectively. The ferrosilicon category of 25% to 65% (nominal 50% ferrosilicon) had the most pronounced year-to-year percentage declines, for which production and shipments decreased by 28% and 27%, respectively. For the ferrosilicon category of 56% to 95% (nominal 75%), production and shipments decreased by 23% and 29%, respectively. Silicon metal production and shipments rose by 23% and 27%, respectively, which were offset by declines in the other silicon product categories (table 2). These comparisons are exclusive of silvery pig iron, statistics for which were not published to avoid disclosing proprietary data. In terms of silicon content, overall production of silicon materials marks the sixth consecutive year of decline from a decade high of 430,000 t in 1997.

[1]References that include a section mark (§) are found in the Internet References Cited section.

Domestic production data for silicon are derived from monthly and annual voluntary surveys and estimates for nonrespondents by the U.S. Geological Survey (USGS). The figures in table 2 represent 100% of the production and shipments from the operations listed in table 3 that are canvassed by means of the Silicon Alloys survey.

Several changes for domestic silicon ferroalloys and metal producers occurred during 2003. Simcala Inc. restarted the third furnace at its Mt. Meigs, AL, silicon metal plant in February; the unit had been closed since August 2001 (Ryan's Notes, 2003f). Later in the year, Dow Corning Corp. purchased Simcala for $30 million after receiving bankruptcy court approval. Simcala reported it would continue to operate under its current name and at current production levels (American Metal Market, 2003).

On April 2, Globe Metallurgical Inc. filed for Chapter 11 bankruptcy protection in the Southern District of New York primarily because of its nonproductive Norwegian assets (Ryan's Notes, 2003g). The company's tolling agreement with Marco International Inc. was expected to remain in place as the bankruptcy restructuring proceeds (Platts Metals Week, 2003a). The company hoped to emerge from Chapter 11 by 2004. In late September, the company closed its Niagara Falls, NY, silicon ferroalloys smelter indefinitely (Ryan's Notes, 2003e).

In late April, Elkem ASA announced plans to reduce staffing by 30% at its silicon metal plant in Alloy, WV, and its former divisional office in Pittsburgh, PA, by the first of August (Elkem ASA, 2003§). The company reported that the plant recorded a weak result for the first quarter in 2003 owing to technical problems caused by flooding and continued problems with the introduction of new electrode technology.

In late September, Globe reached a settlement with silicon metal and ferroalloy producer Fesil Group to sell its 39.9% ownership in Fesil for $4.5 million. As part of the settlement, Globe agreed to transfer its 1.2% ownership in Fesil Group's parent company, GfM Fesil, headquartered in Duisburg, Germany, back to GfM Fesil (Ryan's Notes, 2003a). Globe's Springfield, OR, silicon smelter and associated assets were auctioned on September 30 to MI Capital for $1.5 million (Ryan's Notes, 2003g).

On December 4, Oxbow Carbon and Minerals LLC announced that it had completed its acquisition of Walter Industries, Inc.'s, ferroalloys subsidiary [Applied Industrial Materials Corporation (AIMCOR)] for $127.8 million (Oxbow Carbon and Minerals LLC, 2003§).

Semiconductor-Grade Silicon.—World production of polycrystalline silicon increased by 14% to 23,100 t in 2003 owing to rising demand in solar batteries and in semiconductors for cellular phones and digital consumer products (Roskill's Letter from Japan, 2004a).

Consumption

Silicon Ferroalloys and Metal.—Ferrosilicon was used primarily as a deoxidizing and alloying agent in the production of iron and steel products. Silicon metal, which can be classified into metallurgical and chemical grades, was used by the aluminum industry in the production of cast and wrought products. It also served as the basic raw material in the manufacture of many chemical products and intermediates, such as silicones and silanes. Small quantities of silicon were processed into high-purity silicon for use in the semiconductor industry.

The following discussion on consumption of silicon products in the United States is based on silicon content unless otherwise noted. For 2003, total U.S. apparent consumption of silicon-containing ferroalloys and silicon metal was estimated to have increased slightly to 543,000 t from the revised estimate of 541,000 t in 2002. Apparent consumption increased marginally, by less than 1%, to 302,000 t for ferrosilicon and miscellaneous silicon alloys and to 241,000 t for silicon metal. Increases in net imports for consumption and decreases in producer stocks contributed to the slight increase in ferrosilicon apparent consumption. An increase in production led to the slight rise in silicon metal apparent consumption. The share of total demand accounted for by ferrosilicon and miscellaneous silicon alloys remained at 56%.

Table 4 presents data on U.S. reported consumption and stocks of silicon materials in 2003 on a gross-weight basis. The ratio of reported to apparent consumption on a content basis, in percent, is 43 for ferrosilicon, which includes miscellaneous silicon alloys, and 95 for silicon metal. These percentages were derived based on the typical silicon contents of the silicon materials noted in table 4.

Particularly in iron foundries, metallurgical-grade silicon carbide can substitute for ferrosilicon. Data on North American production and U.S. imports of silicon carbide are reported in the Manufactured Abrasives chapter of the 2003 USGS Minerals Yearbook.

Consumption of ferrosilicon and silicon metal was estimated by CRU International Ltd. to have increased in 2003 throughout the Western World. In terms of contained silicon, ferrosilicon consumption increased to 1.91 million metric tons (Mt) from 1.77 Mt in 2002, and silicon metal consumption increased to about 1.10 Mt from 1.02 Mt. Areas having the largest year-to-year increase in consumption were, for ferrosilicon, Japan and other Asian countries, and for silicon metal, Asian countries (excluding China, Japan, and North Korea) and Western World countries (excluding Cuba, the United States, and Western Europe). In decreasing order of consumption, Western Europe, Japan, and other Asian countries accounted for 71% of the ferrosilicon consumption in 2003. Also in decreasing order of consumption, Western Europe, the United States, and Japan accounted for 79% of the silicon metal consumed in 2003 (CRU Bulk Ferroalloys Monitor, 2004a, b).

Semiconductor Grade Silicon.—Global demand for silicon wafers made from polycrystalline silicon increased by 10% as shipments rose to 5,149 million square inches from 4,681 million square inches in 2002. The corresponding value of the shipments increased by 6% to $5.8 billion from $5.5 billion (Roskill's Letter from Japan, 2004b).

Silicon Fume.—Microsilica (silica fume) is a byproduct from furnaces making silicon metal or ferrosilicon with a silicon content of at least 75%. It is obtained by capturing furnace offgases and fines to use as binder and filler in cements. The global market for fumed silica is estimated to exceed 230,000 tons per year (t/yr) (Interfax Mining & Metals Report, 2002).

Prices

Demand for silicon ferroalloys and metal is determined in the short term less by their prices than by the level of activity in the steel, ferrous foundry, aluminum, and chemical industries. As a result, prices tend to vary widely with changes in demand and supply. The basis for U.S. prices of silicon materials was cents per pound of contained silicon.

Year-average import prices given by Platts Metals Week were, in cents per pound, 45.3 for 75% ferrosilicon and 61.3 for silicon metal; these prices were 38% and 15% higher, respectively, than those of 2002. The year-average North American transaction price for 50% ferrosilicon as calculated from Ryan's Notes listings was 47.7 cents per pound, a 16% increase from that of 2002. The rise in year-average prices for 50% ferrosilicon was the first in 7 years. The price range for silicon metal, in cents per pound, began the year at 58.5 to 60, and generally increased to end 2003 at 64 to 66 cents per pound. The price range for 75% ferrosilicon began the year unchanged from yearend 2002 at 38 to 40 cents per pound, reaching a plateau of 47 to 49 cents per pound in late March, where it remained for 4 weeks, and then generally trended downward to end the year at 44 to 46 cents per pound. The price range for 50% ferrosilicon, in cents per pound, began the year unchanged from yearend 2002 at 47 to 50, rose to 51 to 56 for 9 weeks starting in mid-February, and then ended the year at 46 to 49.

Prices for both grades of ferrosilicon rose based on increased demand from the steel sector. The weak dollar and possible ferrosilicon substitution for silicon carbide by the foundry industry, as silicon carbide prices increased, also contributed to the rise in ferrosilicon prices (Metal Bulletin Research Ferro-alloys Monthly, 2004a). Higher silicon metal prices in the United States were attributed to the rapid escalation of prices in the European Union, which caused a shift in the export market and curbed imports into the United States (CRU Bulk Ferroalloys Monitor, 2003).

Foreign Trade

Compared with those of 2002, total ferrosilicon and silicon metal exports, on a content basis, increased by 21% to 26,200 t. Combined imports of ferrosilicon and silicon metal increased by 11% on a content basis. The biggest year-to-year changes were for exports of silicon metal and imports of ferrosilicon. The ensuing comparisons of foreign trade data were made on the basis of gross weight.

U.S. ferrosilicon exports and their value decreased by 9% and 2%, respectively, from those of 2002. In decreasing order of shipments, Canada and Mexico accounted for 91% of the total 2003 ferrosilicon exports (table 5). Exports of silicon metal increased by 32% and 21% in value from those of 2002. Shipments of high-purity silicon containing more than 99.99% silicon accounted for 94% of the total value for silicon metal exports and 92% of the total value of combined ferrosilicon and silicon metal exports. Exports in the category of "ferrosilicon, other" decreased by 19% from those in 2002. Combined shipments to Canada, Japan, Mexico, Norway, and the Republic of Korea accounted for 79% of the total silicon exports. Shipments to Norway in 2003 were 12% of total silicon exports and about six times those in 2002.

U.S. imports of silicon ferroalloys increased by 30% and 53% in value compared with those in 2002. Imports increased for all significant categories, with the exception of imports in the "ferrosilicon, other" category, which declined by 16% from those in 2002. The imports of nominally 75% ferrosilicon (ferrosilicon category of A55% to 80% silicon, other@) accounted for 83% of total ferrosilicon imports and 83% of total ferrosilicon value, respectively (table 6). No ferrosilicon in the category of "80% to 90% silicon" was imported in 2003 as it was in 2002. A minor amount (66 t, gross weight) of ferrosilicon in the category of "more than 90% silicon" was imported in 2003. Ferrosilicon imports in the category "55% to 80% silicon, other," rose 36% from those of 2002. China was the leading source of ferrosilicon imports at 22%, followed by Venezuela at 16%.

Silicon metal imports fell by 12% to 128,000 t from 146,000 t, and 7% in value, to $220 million from $237 million compared with those in 2002. Imports decreased in all silicon metal categories, except for those in the "99.00% to 99.99% silicon" category, which increased by 2% from those in 2002. The "99.00% to 99.99% silicon" category accounted for 58% of the total value for silicon metal imports, an increase of 2% from those in 2002. The value of this category accounted for 32% of the total value of combined ferrosilicon and silicon imports. Brazil provided the largest volume of the "99.00% to 99.99% silicon" import category at 46%, followed by South Africa at 27%. No silicon metal in the category of "silicon, other," from Russia was imported in 2003 as it was in 2002, owing to the final antidumping duties placed on these imports in early 2003.

For 2003, U.S. net import reliance for ferrosilicon was estimated to have increased to 63% from 50% in 2002 and decreased to 44% from 54% for silicon metal. The overall import reliance for silicon was estimated to have risen to 54% from 52% in 2002.

The general rates of duty that applied to U.S. imports during 2003 were the same as in 2002. These were, on an ad valorem basis, 1.5% for standard 75% ferrosilicon; 1.1% for nominal 75% ferrosilicon that contains more than 3% calcium; 1.9% for ferrosilicon containing 80% to 90% silicon; 5.8% for ferrosilicon containing more than 90% silicon; free for magnesium ferrosilicon and other ferrosilicon; and 5.3% or 5.5% for metal exclusive of the high-purity grade, which is free (U.S. International Trade Commission, 2003a).

Ferrosilicon Imports from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela.—On August 18, the U.S. International Trade Commission (ITC) determined for the third time that U.S. ferrosilicon producers were not materially injured by imports of

ferrosilicon from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela (U.S. International Trade Commission, 2003a§). The negative determination was made in response to the second remand issued by the U.S. Court of International Trade (CIT) on the matter on June 18, 2003. The second remand required the ITC to provide additional evidence supporting the negative determination it made in September 2002 (Elkem Metals Co. v. United States, No. 99-10-00628, CIT Slip Opinion 2003-66). The ITC planned to send its decision and rationale back to the CIT by September 16 (Ryan's Notes, 2003i).

Silicon Metal Imports from Russia.—On February 11, 2003, the International Trade Administration of the U.S. Department of Commerce (ITA) announced its final determination of sales at less than fair value of silicon metal imports from Russia during July 2001 through December 2001. The ITA set the final antidumping margins for ZAO Kremny, SUAL-Kremny-Ural Ltd. (54.77%); Bratsk Aluminum Smelter (77.51%); and Russia-wide (77.51%) (International Trade Administration, 2003c).

On March 7, 2003, the ITC made a final determination that the U.S. silicon industry was injured by the subject silicon metal, and transmitted its determination to the Secretary of the U.S. Department of Commerce on March 19 (U.S. International Trade Commission, 2003b). On March 13, the ITA amended the antidumping margins to correct ministerial errors it made in setting the final margins in February 2003 by increasing the margins for ZAO Kremny, SUAL-Kremny-Ural Ltd. from 54.77% to 56.11%; and Bratsk Aluminum Smelter from 77.51% to 79.42% (International Trade Administration, 2003b). The ITA issued an antidumping duty order on these imports on March 26 (International Trade Administration, 2003a). The order also documented an increase in the final Russia-wide antidumping margin from 77.51% to 79.42%.

Several appeals of the ITC's final antidumping ruling on Russian silicon metal imports were filed in late April 2003. The following companies separately appealed the ITC decision that the imports had injured or threatened to injure U.S. silicon producers: General Electric Company and Russian silicon producers SUAL-Kremny-Ural, Ltd. and Bratsk Aluminum Smelter (Platts Metals Week, 2003b; Ryan's Notes, 2003d). The U.S. silicon producers who filed the antidumping complaint, Globe Metallurgical, Inc. and Simcala, Inc., also appealed the antidumping margin rates on the basis that they were too low (Platts Metals Week, 2003b).

Pending U.S.-Southern African Customs Union Free Trade Agreement.— In April, the ITC submitted its confidential probable economic effect report on the pending Southern African Customs Union Free Trade Agreement (FTA) to the United States Trade Representative (USTR) (U.S. International Trade Commission, 2003b§). A public version of the report has not yet been released.

On June 2, the USTR launched negotiations for the FTA with the member nations of the Southern African Customs Union: Botswana, Lesotho, Namibia, South Africa, and Swaziland (Office of the United States Trade Representative, 2003§). The FTA could result in the elimination of the 5.5% ad valorem duty on imports of less than 99.00% silicon metal from South Africa.

Antidumping Duty Administrative Reviews.—The ITA initiated and conducted various antidumping duty administrative reviews on silicon metal during 2003. On March 7, 2003, the ITA rescinded its new shipper and administrative reviews for imports of silicon metal from the People's Republic of China (PRC) by the China Shanxi Province Lin Fen Prefecture Foreign Trade Import and Export Corp. after the company withdrew its requests (International Trade Administration, 2003f). The new shipper period of review covered silicon metal imported from June 1, 2001, through January 14, 2002; the administrative review covered silicon metal imports during the period June 1, 2001, through May 31, 2002. As a result, imports from the company are subject to the PRC-wide antidumping margin rate of 139.49%.

On March 10, 2003, the ITA announced the preliminary results of its administrative review of silicon metal imports from the PRC for Groupstars Chemical Co., Ltd., covering the period June 1, 2001, through May 31, 2002 (International Trade Administration, 2003e). Imports from the company are subject to the PRC-wide antidumping margin rate of 139.49%.

On June 27, the CIT sustained the final antidumping duty margin of 67.93% on imports of silicon metal from Electrosilex S.A. issued by the ITA on January 22, 2003, for the July 1, 1996, to June 30, 1997, period of review (American Silicon Technologies v. United States, No. 99-03-00149, Slip Opinion 2003-69). The ITA applied the 67.93% duty rate that was calculated for Companhia Brasileira Carbureto de Calcio (CBCC) in the fourth administrative review of silicon metal imports from that company to Electrosilex as the "adverse facts available rate" (International Trade Administration, 2003a§). However, the CIT stayed its June 27 order on October 30 pending the outcome of the fourth administrative review of the antidumping duty order on silicon metal from Brazil (American Silicon Technologies v. United States, No. 97-02-00267).

On July 3, the U.S. Court of Appeals for the Federal Circuit (CAFC) upheld CBCC's appeal of the 67.93% duty rate the ITA applied to silicon imports from the company during July 1, 1994, through June 30, 1995 (U.S. Court of Appeals for the Federal Circuit, 2003§). The ITA assessed the duty rate in 1999, and the CIT sustained it on August 27, 2001 (American Silicon Technologies v. United States, No. 97-02-00267, Slip Opinion 2001-109). The CAFC concluded the CIT had sharply limited the ITA's ability to calculate the duty rate by precluding the consideration of the consolidated financial statements of CBCC's ultimate parent, Solvay & Cie. As a result, the CAFC remanded the case back to the ITA, and the ITA recalculated the dumping margins for the subject imports at a de minimis level of 0.37%. The duty rate will be assessed to the subject imports upon review and an affirmative decision by the CIT (International Trade Administration, 2003b§).

On August 22, the ITA announced the beginning of an antidumping duty investigation on silicon metal imports from Brazilian producers CBCC and Companhia Ferroligas Minas Gerais-Minasligas, for the period July 1, 2002, through June 30, 2003. The ITA expects to issue final results of the review by July 31, 2004 (International Trade Administration, 2003d).

World Review

Data on annual world production of ferrosilicon and silicon metal by country during 1999 through 2003 are given in the Ferroalloys chapter of the 2003 USGS Minerals Yearbook. World production of ferrosilicon was estimated to have been 4.90 Mt in 2003

compared with a revised total of 4.22 Mt in 2002. The major ferrosilicon producers in 2003 were, in decreasing order, China, Russia, Norway, Ukraine, Brazil, South Africa, the United States, Kazakhstan, and Iceland; they accounted for 87% of total production as listed in table 1. World production of silicon metal, excluding that from China, was estimated to have been 642,000 t in 2003 compared with a revised total of 615,000 t in 2002. China's production of silicon metal is believed to have been the world's largest, but firm data are lacking. China's output of silicon metal in 2003 was estimated at about 550,000 t based on reported export and estimated consumption levels. Other major producers of silicon metal in 2003 were, in decreasing order, Brazil, the United States, Norway, France, Russia, South Africa, and Spain; they accounted for about 84% of total production as listed in table 1.

European Union.—In July, the European Court of the First Instance reaffirmed the European Commission's March 2001 decision to lift antidumping duties on ferrosilicon imports from China, Kazakhstan, Russia, Ukraine, and Venezuela (Ryan's Notes, 2003c).

In early December, the European Commission voted to impose final antidumping duties on silicon metal imports from China (49%) and from Russian producers SUAL-Kremny-Ural Ltd. (22.7%) and Bratsk Aluminum (23.6%) (Ryan's Notes, 2003b).

China.—In 2003, China's exports of ferrosilicon rose about 58% to an alltime high of 809,000 t from a revised figure of 513,000 t in 2002 (TEX Report, 2004a). China exported about 479,000 t of silicon metal in 2003, an increase of 24% from that in 2002 (TEX Report, 2004c).

In November, the Inner Mongolia Electric Power Metallurgy Co. Ltd. of the ERDOS Group started production at its new ferrosilicon plant in the City of Wuhai, Inner Mongolia Autonomous Region (TEX Report, 2004d). The facility is expected to have a production capacity of 500,000 t/yr upon completion by yearend 2004, with plans to add 200,000 t/yr of silicon metal production capacity in the future (TEX Report, 2004b).

Germany.—Polysilicon producer Wacker-Chemie announced it would raise polysilicon production capacity at Burghausen, Germany, to 5,000 t/yr from 4,200 t/yr by mid-2004. The company stated that it would move its polysilicon business from the Wacker Siltronic silicon wafer subsidiary to create a new stand-alone unit, Wacker Polysilicon, effective January 1, 2004. The company also announced it had begun construction on a new silicon metal grinding plant at Nünchritz, Germany, with completion set for 2005 (Chemical Week, 2003g).

Iceland.—Elkem ASA purchased additional shares in ferrosilicon producer Icelandic Alloys Ltd. during the fourth quarter, which raised Elkem's stake in the company to 98% by yearend 2003 (Elkem ASA, 2004§).

Philippines.—In March, the Mindanao Silicon Metal Corp. opened a new silicon smelter on the Philippine Mindanao Island, operating one furnace at a monthly production rate of 400 metric tons. The company planned to start a second furnace in September 2003 and a third by January 2004 (Ryan's Notes, 2003j).

Russia.—In July, the Russian Government announced it would raise the duty on silicon metal imports to 20% from 5%, but not less than €160 (U.S. $180.26) per metric ton. Most of the silicon metal imported into the country is from China (Ryan's Notes, 2003h).

Russian Aluminum put its Bratsk, Russia, silicon and ferrosilicon smelter up for sale. Silicon metal production was limited to that containing 1% iron, most of which was sold to U.S. secondary aluminum producers via resellers. The company decided to sell the plant after 1) losing its U.S. market because of recently imposed U.S. duties on Russian silicon metal imports and 2) European buyers' lack of interest in purchasing 1% ferrosilicon (Ryan's Notes, 2003a). According to Rusal, the plant produced 17,400 t of silicon and 34,766 t of ferrosilicon in the first 10 months of 2003 (Mining Journal, 2003).

In November, Kuznetsky Ferrosplavy (KFZ) re-commissioned the No. 6 ferrosilicon furnace at its ferroalloys plant in Novokuznetsk after a 2-month overhaul. As a result, KFZ's production of ferrosilicon containing 45% silicon fell by 1.1% to about 336,000 t in 2003 (Interfax Mining & Metals Report, 2004a).

Thailand.—Degussa AG announced that it plans to build a fumed silica plant in Map Ta Phut, Thailand, adjacent to a siloxanes complex being built by Asia Silicone Monomer (joint venture between GE Toshiba Silicones and Shin-Etsu Chemical). The company expected the plant, which will have an annual production capacity of several thousand tons, to be operational in the first-half of 2004. The plant will be operated by a newly established Degussa subsidiary, Thai Aerosil Co. (Chemical Week, 2003b).

Ukraine.—Stakhanov Ferroalloy Works shut down production at its ferrosilicon plant in September because of an increase in electricity prices following a change in suppliers. The plant resumed operation in March 2004 in response to higher prices on the world market (Interfax Mining & Metals Report, 2004b).

Current Research and Technology

Several noteworthy items about silicon materials were found in the current literature—

Silicon in Computer Chips.—Intel Corporation identified candidates to replace silicon-based materials in the next-generation of computer chip, including those based on hafnium and zirconium that could replace silicon dioxide as the transistor's gate dielectric, as well as undisclosed metals that could replace polysilicon in the gate electrode. The company reported the system could be implemented in its 45-nanometer chip manufacturing process scheduled for 2007 (Chemical Week, 2003e). Surmet Corporation announced a new ultra-high-purity silicon coating designed to prevent wafer contamination from microparticles (Advanced Materials & Processes, 2003).

Nanotechnology.—Researchers at the University of Minnesota and Los Alamos National Laboratory reported silicon nanospheres 40 to 100 nanometers in diameter are up to four times as hard as bulk silicon, such as the silicon wafers from which computer chips are made, placing them between the two hardest materials, sapphire and diamond (Science News, 2003). Researchers from Rice University and the University of Texas announced that silica nanoshells coated with gold could be used to treat otherwise inoperable tumors (Chemical Week, 2003f).

Silicones.—General Electric Plastics introduced the first transparent polycarbonate (PC)-silicone copolymer to replace standard PC grades and competing transparent materials in applications such as building materials, eyewear, lighting, medical devices, and water bottles (Chemical Week, 2003d).

Outlook

Demand for ferrosilicon follows trends in the iron and steel industries, for which the combined annual growth rates (CAGRs) have been typically in the range of 1% to 2%. Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2003 USGS Minerals Yearbook. Raw steel production in 2003 increased by 2% in the United States and about 7% globally. According to the International Iron and Steel Institute (IISI), apparent consumption of finished steel products increased to 864 Mt in 2003 from 805 Mt in 2002, an increase of 7% (International Iron and Steel Institute, 2004§). This increase was primarily attributed to steel consumption in China; steel consumption in the rest of the world rose to 631 Mt in 2003 from 619 Mt in 2002, an increase of 2%. Outside of Asia, steel consumption in most regions of the world rose nominally, with the exception of Africa and North America, where steel consumption decreased by 2%. Globally, ferrosilicon consumption in the iron and steel industries in 2003 was expected to increase by roughly 3% to 1.90 Mt from a revised figure of 1.85 Mt in 2002 (Metal Bulletin Research Ferro-alloys Monthly, 2004b). The IISI projected North America's GDP and steel use to rise 3.7% and 5.3%, respectively, in 2004 compared with that of 2003 (Christmas, 2003§).

Demand for silicon metal comes primarily from the aluminum and chemical industries. The American Chemistry Council estimated a 3.3% gain in chemical volumes and a 4.5% increase in domestic chemical shipments as a result of improving economic recovery in 2004 (Chemical Week, 2003a; American Chemistry Council, 2003§). Demand for silicon by the U.S. aluminum castings industry was expected to mirror the 7.1% increase in aluminum casting shipments forecasted for 2004 (Kirgin, 2004§). Total world silicon metal consumption was expected to increase by 4% to 1,025 Mt in 2003 from a revised figure of 987 Mt in 2002 (Metal Bulletin Research Ferro-alloys Monthly, 2004c).

As a rough indicator of demand, world production of polycrystalline silicon was forecasted to increase by about 8% to 25,000 t in 2004. The market was expected to be in balance during 2004, but if demand continues to rise at a rate of 10% per year, a supply shortage may emerge in 2005 (Roskill's Letter from Japan, 2004a).

Demand for microsilica comes from the cement industry. Worldwide demand for cement was projected to rise 4.1% annually through 2006 to 2.1 billion metric tons, although advances were expected to be less robust in more developed areas such as the United States, Japan, and Western Europe (Mining Engineering, 2002).

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TABLE 1
SALIENT SILICON STATISTICS[1]

(Thousand metric tons of silicon content unless otherwise specified)

	1999	2000	2001	2002	2003
United States:					
Production	423	367	282	261	248
Exports:					
Ferrosilicon	24	22	10	7	6
Silicon metal	37	19	12	15	20
Imports for consumption:					
Ferrosilicon	173	231	115	140	189
Silicon metal	113	130	116	145	126
Apparent consumption:					
Ferrosilicon	374	397	258	301	302
Silicon metal	269	292	244	240 r	241
Price, average, cents per pound Si:					
Ferrosilicon, 50% Si[2]	49.10	45.00	42.80	41.10	47.70
Ferrosilicon, 75% Si[3]	40.20	35.40	31.90	32.90 r	45.30
Silicon metal[4]	58.10	54.80	50.50	53.20	61.30
World:					
Production,m gross weight:[e]					
Ferrosilicon	3,900	4,240	4,030 r	4,220 r	4,900
Silicon metal	681	729	629	615 r	642

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits.
[2]Ryans Notes North American transaction prices based on weekly averages.
[3]Platts Metals Week mean import prices based on monthly averages.
[4]Platts Metals Week dealer import prices based on monthly averages.

TABLE 2

PRODUCTION, SHIPMENTS, AND STOCKS OF SILICON ALLOYS AND METAL IN THE UNITED STATES[1, 2]

(Metric tons, gross weight, unless otherwise specified)

Material	Silicon content (percentage)		2002	2003		
	Range	Typical	Producers' stocks, December 31	Gross production[3]	Net shipments	Producers' stocks, December 31
Ferrosilicon[4]	25-65 [5]	48	19,400	113,000	76,100	10,200
Do.	56-95	76	15,800	75,800	73,600	12,400
Silicon metal (excluding semiconductor grades)	96-99	98	3,600 [r]	139,000	133,000	5,520

[r]Revised.

[1]Data are rounded to no more than three significant digits.

[2]Data for silvery pig iron (less than 25% silicon) withheld to avoid disclosing company proprietary data.

[3]Ferrosilicon production includes material consumed in the production of miscellaneous silicon alloys.

[4]Includes miscellaneous silicon alloys, which formerly was listed separately.

[5]25% to 55% for ferrosilicon; 32% to 65% for miscellaneous silicon alloys.

TABLE 3
PRINCIPAL PRODUCERS OF SILICON ALLOYS AND/OR SILICON METAL IN THE UNITED STATES IN 2003

Producer	Plant location	Product[1]
Applied Industrial Minerals Corp.[2]	Bridgeport, AL	FeSi.
CC Metals and Alloys, Inc.	Calvert City, KY	Do.
Elkem Metals Co.	Alloy, WV	FeSi and Si.
Globe Metallurgical, Inc.	Beverly, OH	Do.
Do.	Niagara Falls, NY	Do.
Do.	Selma, AL	Si.
Simcala, Inc.	Mt. Meigs, AL	Do.

[1]FeSi, ferrosilicon; Si, silicon metal.
[2]Acquired by Oxbow Carbon and Minerals LLC in December 2003.

TABLE 4
REPORTED CONSUMPTION, BY END USE, AND STOCKS OF SILICON FERROALLOYS AND METAL IN THE UNITED STATES IN 2003[1, 2]

(Metric tons, gross weight, unless otherwise specified)

End use	Silvery pig iron[3]	Ferrosilicon, 50%[4]	Ferrosilicon, 75%[5]	Silicon metal[6]	Miscellaneous silicon alloys[7]	Silicon carbide[8]
Steel:						
Carbon and high-strength, low-alloy	W	(9)	15,500	793	(9)	(9)
Stainless and heat-resisting	--	(9)	42,500	387	(9)	3,910
Full alloy	--	(9)	5,680	172	(9)	--
Electric and tool	--	(9)	26,800	--	(9)	(9)
Unspecified	--	25,600	(10)	(10)	1,020	8,520
Total	--	25,600	90,500	1,350	1,020	12,400
Cast irons	4,830	40,400	29,200	(10)	15,600	34,300
Superalloys	--	(11)	(10)	82	--	--
Alloys (excluding superalloys and alloy steel)	W	404	(10)	176,000 [12]	--	--
Miscellaneous and unspecified	--	(11)	91	55,100	(11)	--
Grand total	4,830	66,400	120,000	233,000	16,600	46,800
Consumers' stocks, December 31	333	1,620	7,980	1,840	933	1,440

W Withheld to avoid disclosing company proprietary data. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes U.S. Geological Survey estimates.

[3]Typically 18% silicon content but ranges between 5% to 24% silicon content.

[4]Typically 48% silicon content but ranges between 25% to 55% silicon content; includes briquets.

[5]Typically 76% silicon content but ranges between 56% to 95% silicon content; includes briquets.

[6]Typically 98% silicon content but ranges between 96% to 99% silicon content.

[7]Typically 48% silicon content. Primarily magnesium-ferrosilicon but also includes other silicon alloys.

[8]Typically 64% silicon content but ranges between 63% to 70% silicon content. Does not include silicon carbide for abrasive or refractory uses.

[9]Included with "Steel: Unspecified."

[10]Included with "Miscellaneous and unspecified."

[11]Included with "Cast irons."

[12]Primarily silicones, silanes, fumed silica, and other chemicals, plus aluminum alloys.

TABLE 5

U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2003[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
More than 55% silicon:			
Canada	4,470	2,680	$3,640,000
Colombia	4	3	5,130
Malaysia	33	25	54,800
Mexico	1,310	792	1,360,000
Total	5,820	3,500	5,070,000
Other ferrosilicon:			
Australia	24	12	29,300
Brazil	116	53	143,000
Canada	3,400	1,700	2,990,000
France	18	9	15,000
Germany	9	3	11,700
Italy	65	34	105,000
Korea, Republic of	656	328	701,000
Malaysia	20	10	22,800
Mexico	1,390	687	1,280,000
Spain	13	6	11,900
Other	63	18	62,100
Total	5,780	2,860	5,370,000
Grand total ferrosilicon	11,600	6,370	10,400,000

See footnotes at end of table.

TABLE 5--Continued

U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2003[1]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Metal:			
More than 99.99% silicon:			
China	942	XX	$26,500,000
France	146	XX	3,540,000
Germany	650	XX	20,300,000
Italy	4,370	XX	186,000,000
Japan	597	XX	25,000,000
Korea, Republic of	80	XX	13,300,000
Norway	560	XX	14,200,000
Taiwan	196	XX	7,110,000
Ukraine	93	XX	2,520,000
United Kingdom	219	XX	20,700,000
Other	436	XX	28,200,000
Total	8,290	8,290 [e]	347,000,000
99.00% - 99.99% silicon:			
Brazil	673	667	1,680,000
Colombia	104	103	150,000
France	78	78	110,000
Italy	398	394	702,000
Jamaica	9	9	15,300
Japan	21	20	48,200
Mexico	272	269	438,000
Norway	530	525	894,000
Singapore	7	7	9,020
Venezuela	49	49	74,100
Other	112	111	205,000
Total	2,250	2,230	4,330,000
Other silicon:			
Canada	2,370	2,300	2,620,000
China	212	206	280,000
Hong Kong	149	144	408,000
Italy	139	135	245,000
Japan	1,610	1,560	2,460,000
Korea, Republic of	189	184	260,000
Mexico	820	796	1,820,000
Netherlands	789	759	4,190,000
Norway	2,560	2,480	3,370,000
United Kingdom	473	459	566,000
Other	297	289	586,000
Total	9,600	9,320	16,800,000
Grand total silicon metal	20,100	19,800	368,000,000

[e]Estimated. XX Not applicable.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2003[1]

(Metric tons)

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
55% - 80% silicon, more than 3% Ca:			
Argentina	680	341	$657,000
Brazil	1,100	817	814,000
Canada	41	30	16,400
China	19	3	14,200
France	180	107	242,000
Germany	6	4	6,000
Mexico	15	10	55,400
Total	2,040	1,310	1,800,000
55% - 80% silicon, other:			
Brazil	6,050	4,620	3,590,000
Canada	14,500	10,900	9,860,000
China	52,100	39,200	30,000,000
France	4,040	2,560	7,720,000
Iceland	20,400	15,300	12,400,000
Kazakhstan	31,700	24,200	22,300,000
Norway	11,600	8,620	10,100,000
Russia	28,800	19,900	16,500,000
Ukraine	6,260	4,720	3,670,000
Venezuela	42,900	34,400 [2]	29,200,000
Other	6,340	4,740	5,570,000
Total	225,000	169,000	151,000,000
More than 90% silicon:			
Canada	57	46	26,700
South Africa	9	7	3,350
Total	66	53	30,100
Magnesium ferrosilicon:			
Argentina	2,770	1,280	1,970,000
Brazil	4,470	2,010	2,740,000
Canada	2,540	1,220	1,930,000
China	6,120	2,760	4,170,000
France	100	35	113,000
India	114	58	116,000
Japan	455	206	503,000
Netherlands	968	451	785,000
Norway	12,600	5,800	10,200,000
Sweden	104	53	98,800
Other	48	25	106,000
Total	30,300	13,900	22,700,000
Other ferrosilicon:			
Argentina	59	27	54,700
Brazil	787	363	583,000
Canada	8,510	2,800	5,340,000
China	83	37	85,000
France	34	18	75,000
Russia	2,700	1,670	1,420,000
Ukraine	11	5	7,030
Total	12,200	4,910	7,570,000
Grand total ferrosilicon	270,000	189,000	183,000,000

See footnotes at end of table.

TABLE 6--Continued
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2003[1]

(Metric tons)

Country	Gross weight	Contained weight	Value
Metal:			
More than 99.99% silicon:			
Belgium	12	XX	$48,000
China	37	XX	512,000
Finland	9	XX	29,100
Germany	324	XX	40,600,000
India	14	XX	18,900
Italy	340	XX	15,200,000
Japan	467	XX	14,300,000
Korea, Republic of	160	XX	981,000
Poland	9	XX	34,600
Spain	8	XX	43,600
Other	17	XX	1,020,000
Total	1,400	1,400 [e]	72,900,000
99.00% - 99.99% silicon:			
Argentina	754	750	714,000
Australia	4,360	4,090 [2]	4,670,000
Brazil	49,100	48,800	57,500,000
Canada	14,900	14,800	17,700,000
China	269	263	240,000
Kazakhstan	520	515	517,000
Korea, Republic of	120	119	96,000
Malaysia	300	297	309,000
Norway	5,940	5,790	10,700,000
South Africa	28,400	28,200	32,300,000
Other	1,270	1,230	2,370,000
Total	106,000	105,000	127,000,000
Other silicon:			
Brazil	1,910	1,890	1,930,000
Canada	2,550	2,420	2,650,000
China	2,550	2,510	2,260,000
Germany	320	297	319,000
Kazakhstan	240	233	190,000
Norway	1,110	1,100	1,160,000
South Africa	9,270	9,100	8,850,000
Ukraine	680	669	638,000
United Arab Emirates	319	314	264,000
United Kingdom	580	565	636,000
Other	850	612	911,000
Total	20,400	19,700	19,800,000
Grand total silicon metal	128,000	126,000	220,000,000

[e]Estimated. XX Not applicable.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Data was adjusted by the U.S. Geological Survey.

Source: U.S. Census Bureau.